Meteor Shower of Halley's Comet. By W. F. Denning.

There is perhaps no star-shower which has, in recent years, stood so much in need of re-observation as the brilliant display of Aquariads discovered by Lieut.-Col. Tupman while cruising off the east coast of Sicily on the mornings of May 1 and 3, 1870. But the radiant point at 325°–2½°, 5° preceding *α Aquarii*, as determined on that occasion, does not rise in our latitude until just before daylight, so that the only prospect of recovering the shower was by morning watches, necessarily rendered very brief and imperfect by the prevailing twilight of the season. These circumstances enabled the shower to elude subsequent observation.

Heis had recorded that on May 2, 1848, he observed many falling stars with bright streaks ("viele Sternschnuppen mit hellen Schweifen"), but it is extremely uncertain whether this relates to a veritable pre-apparition of the special shower witnessed by Col. Tupman.

Observing just before daylight on May 4, 1878, Mr. Corder registered three meteors of this stream. He describes them as notable for great length of path, and found the radiant at 334°–1° (*Observatory*, vol. ii. p. 103). A few other paths observed by him at various times afterwards led him to place the centre at 334°–5°, April–May (*Monthly Notices*, xi. p. 135).

Contemporary with Col. Tupman's observations in 1870, a number of diligent observers were recording meteors in the clear Italian sky, and the materials they accumulated were published at Milan in 1882. I projected 229 paths given in this Catalogue for the interval April 29—May 6, between 13^h and $15\frac{1}{2}^h$, and found that about forty-five of these belonged to the display of Aquariads. The meteors were very bright, with streaks and singularly long trajectories, and their radiant point was indicated at about 335°–9° (*Monthly Notices*, xliii. p. 111–14). This value exhibited such a large discordance with that determined by Col. Tupman that it became more than ever necessary to secure new observations. This was rendered all the more imperative from the suggestive resemblance in date and place of the meteor shower with the computed radiant for Halley's comet (1835, iii.) at its nearest appulse to the earth's orbit on May 4, twelve days preceding its passage through the descending node. Prof. Herschel gives the point 337° ± 0°, May 4, as the theoretical radiant of meteoric particles from this comet (*B.A. Report on Luminous Meteors*, 1874, p. 349), and points out that the agreement with Col. Tupman's shower of 1870 is a significant one, notwithstanding the difference of 10° or 12° in their radiant points.

At the return of this shower in the present year we had a succession of very clear nights, and (the moon being absent) I obtained observations on April 25, 26, 27, 30, May 1, 3, 4, 5, 6, 8 and 9: 117 shooting stars were recorded in watches extending

over 27½ hours. On the whole, I found meteors extremely rare, the horary rate being about four. On May 3, though the atmosphere was highly transparent and the stars unusually brilliant during the five hours I continued to watch, only twenty-one were seen. Again, on May 5, not more than twenty-four were counted in four hours. I have frequently seen meteors four or five times as numerous as this on clear nights in the autumn.

On April 30 and following nights the Aquariads were well observed, and formed the best display of the epoch. I found them fairly conspicuous meteors with dense, flaky streaks, and their lines of flight covered extensive arcs. The average length of twelve paths was 39°·0, whereas the average length of ordinary meteors, derived from all my observations, is 11°·2. (The average of the forty-five conformable tracks registered by the Italian observers in 1870 was 34°·7.) I recorded the motions as ranging between slow and swift. These Aquariads are remarkable for their long, graceful flights, rather than for any extreme degree of visual velocity, though were the radiant higher, they would doubtless appear much swifter, and their apparent paths must cease to exhibit abnormal length.

The bright streaks generated by these meteors are very useful as affording the means of recording their directions with great accuracy. From twelve paths I find the radiant at $337° - 2\frac{1}{2}°$, which must be within 2° of probable error. Nine of the meteors agree well with this position, and the three remaining tracks pass within a few degrees of it, but the radiant may be diffuse to the extent of 5° or 7°, for I cannot otherwise explain the three slightly discordant meteors, the directions in each case having been well observed.

The radiant point of this shower is therefore close to *η Aquarii* and 11° W. of a mean of three positions given by Col. Tupman. It agrees so closely with the radiant of Halley's comet, and among other favouring circumstances, the shower is one of such pronounced and definite character, that the identity of the two orbits seems placed beyond doubt. Comparing the radiants, we have the following figures:—

Halley's Comet	May 4	$337° \pm 0°$
Tupman's Aquariads	April 30–May 6	$337 - 2\frac{1}{2}$

The maximum occurs on May 6 according to my recent observations. At the time of nearest approach to the Earth the comet's orbit is 0·061 (Sun's distance = 1) below the Earth, which is equivalent to nearly $5\frac{3}{4}$ millions of miles. This interval is relatively inconsiderable when we remember to what enormous distances from the nucleus the material of the comet probably extends. The facts appear to present another excellent instance of agreement between a periodical comet and a very conspicuous meteor shower. The latter should now be specially looked for at observatories much further south, where the conditions are more favourable. In our latitude the radiant at $337° - 2\frac{1}{2}°$ does

not clear the horizon until about $13^h\ 45^m$, when daybreak is already becoming strong in the N.E. sky. At southern stations, however, there would be a longer interval available for observation, and the greater elevation of the radiant must greatly enhance the richness of the shower. But while the low altitude of the radiant, as seen from this country, detracts from the numerical strength of the display, it has the effect of increasing the conspicuous aspect of the meteors, and their long flights right across the firmament create an impression not soon forgotten.

The following are the observed paths of eleven Aquariads recently seen here, and one recorded in 1880:—

No.	Date.	h	m	Mag.	Path From $\alpha_\circ$	From $\delta_\circ$	To $\alpha_\circ$	To $\delta_\circ$	Length of Path.	Appearance.
1	1880, May 2	14	23	3	324	+14	311	+28	18	Slowish; streak.
2	1886. Apr. 30	14	48	3	346	+30	355	+54	25	Swift; streak.
3	May 1	14	37	3	300	− 2	280	− 0½	19	Swift; streak
4	3	14	31	3	345½	+43	135	+68	66	Slowish; streak.
5	4	14	20	2	310	+ 3	270	+11	41	Slowish; streak.
6	5	14	6	4	334½	+28	327	+68	40	Slow; streak.
7	5	14	18	2	301	−16	270	+23½	30	Swift; streak.
8	6	13	55	4	323	+30½	224	+79	62	Slowish; streak.
9	6	14	11	2	306½	+21	202	+31	87	Slow; streak.
10	6	14	28	5	299	+24	274	+33	22	Rather swift.
11	6	14	32	4	334	+22½	332	+33	10½	Swift; streak.
12	6	14	36	3	301	+19½	250	+38½	47	Slowish; streak.

May 2 and 7 were cloudy, and May 8 clear only in the early part of the night. On May 9 I obtained a good view of the eastern sky between 14^h and 15^h, and saw six meteors, but the radiant in *Aquarius* gave no sign of continued activity.

I cannot account for the wide difference between my radiant point and that adopted by Col. Tupman. To get a good centre I took the precaution to watch the S.E. and N.E. sky alternately, so as to secure paths placed nearly at right angles. If Col. Tupman observed these Aquariads chiefly in the southern sky the motions would be in Right Ascension, and would give the Declination of the radiant well, while the R.A. would probably be doubtful to the extent of 10° or 15°. This is the most feasible explanation of the discordance that occurs to me.

The fine shower of Aquariads which, with early Perseids, form the well-defined meteoric epoch of July 27–30, have a radiant point at about 340°–12°, near δ *Aquarii*, and ten degrees south of the May Aquariads.

My late observations supply definite evidence of a considerable number of minor radiant points. The best of these are at 234°+10°, near α *Serpentis*, at 254°−21°, near ρ *Ophiuchi*, at 189°+58°, near ϵ *Ursæ Majoris*, and at 239°+46°, on the N.W. borders of *Hercules*.

Bristol: May 11, 1886.

Observations of Comets d 1885 (*Fabry*), *e* 1885 (*Barnard*), *and a* 1886 (*Brooks*), *made at the Royal Observatory, Greenwich.*

(*Communicated by the Astronomer Royal.*)

The observations were made with the East or Sheepshanks Equatorial, aperture 6·7 inches, by taking transits over two cross wires at right angles to each other, and each inclined 45° to the parallel of Declination.

Comet d 1885.

	Greenwich Mean Solar Time.	Observer.	∥−∗ R.A.	Corr. for Par. and Refract. in R.A.	∥−∗ N.P.D.	Corr. for Par. and Refract. in N.P.D.	No. of Comp.	Apparent R.A.	Apparent N.P.D.	Comp Star.
1886.	h m s		m s	s	′ ″	″		h m s	° ′ ″	
April 9	15 21 31	H. T.	+2 42·83		− 1 24·6		3			*a*
	15 21 31		+2 33·90		+ 8 36·6		3			*b*

Comet e 1885.

April 25	9 36 49	H.	+6 22·70	−0·10	+ 5 28·8	+ 5·0	4	1 40 13·35	50 5 32·1	*c*
	9 40 44		−7 30·20	−0·90	+11 10·8	+32·7	1	1 40 15·52	50 6 9·7	*d*
	9 59 45		+4 12·80	+0·24	− 6 25·4	−22·2	1	1 40 6·12	50 5 10·7	*e*
26	9 14 24	L.	+6 44·50	+0·48	− 7 45·2	−17·0	1	1 40 35·79	49 52 8·7	*f*
	9 18 57		+7 16·75	+0·28	− 1 37·9	− 9·9	2	1 40 38·58	49 51 59·2	*g*
May 3	13 33 45	H. T.	−0 33·88	−0·43	− 3 30·1	−11·1	6	1 38 57·03	49 31 44·3	*h*